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Original Article

Black hair dye dermatitis: Still a major skin problem and commonly mimicking chronic actinic dermatitis

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ABSTRACT

Background: Hair dye dermatitis is a common, increasingly frequent dermatological problem that can be seen as localized or generalized dermatitis with different clinical patterns such as lichenoid photosensitivity, dermatitis, and angioedema. **Objective:** The aim of the present study was to do a full clinical and epidemiological assessment of patients with hair dye dermatitis within a limited period of time. **Patients and Methods:** This was a cross-sectional, descriptive case study that began in January 2014 and ended in December 2022, aiming to record all cases of hair dye dermatitis during this period. Full epidemiological and demographic features were recorded. Also, history taking and clinical examination of the patients were performed. Biopsies were taken for histopathological assessment. **Results:** A total of 234 patients with hair dye dermatitis were analyzed and assessed; their ages ranged from 32 to 60 years, with a mean of 50 years, with 189 (80.8%) males and 45 (19.2%) females, with a ratio of 4:1. All patients had applied black hair dye. The frequency of these cases among years showed an upsurge-curve as follows: 2014: 6 (2.6%), 2015: 12 (5.1%), 2016: 42 (17.9%), 2017:50 (21.4%), 2018: 42 (17.9%), 2019: 33 (14.2%), 2020: 13 (5.5%), March 2021: 6 (2.6%). The years 2020 and 2021 could be excluded because of COVID-19, while the year 2022 included 30 (12.8%) cases. The sites of rash were as follows: face in 159 (67.9%); neck and V area of the chest in 120 (51.2%); scalp in 60 (25.6%); limbs and trunk in 60 (25.6%) patients. The patterns of facial rash were acute angioedema in 32 (13.7%) cases, erythematous dermatitis in 36 (15.4%), and pigmented lichenoid photodermatitis in 166 (70.9%). This chronic state exactly mimics chronic actinic dermatitis. In addition, 102 (43.6%) patients had facial melanosis as separate or combined with other features of hair dye dermatitis. The histopathological assessment showed features of acute and chronic dermatitis. **Conclusion:** There was a sharp rise-decline curve in black hair dye dermatitis within six years. It was a disease of middle-aged male patients, and the most common presentation was chronic pigmented lichenoid photodermatitis with or without extrafacial involvement, and the clinical picture was similar to chronic actinic dermatitis. Many patients presented mainly with facial melanosis. Black hair dye dermatitis is now a great mimicker disease, hence any adult patient with dermatitis and hair dye dermatitis should be excluded.

Key words: Hair dye, PPD, Lichenoid photodermatitis, Angioedema, Facial melanosis, Chronic actinic dermatitis

INTRODUCTION

The hair filament is a protein filament that grows from hair follicles located in the dermis of the skin. There are four components to each strand of hair, namely the medulla, cortex, cuticle, and cell membrane complex (CMC) [1]. It is believed that two types of hair pigments contribute to the natural color of hair. It is important to understand that both types of pigments are melanin, which is produced inside the hair follicle and packaged into tiny granules within the fibers of the hair. It is thought that gray hair is caused by a decrease in or stoppage of melanin production [2,3].

As an ancient art, dyeing of the hair is a process in which the hair is exposed to a solution of propylene

How to cite this article: Sharquie KE, Abdulwahhab WS, Sharquie IK. Black hair dye dermatitis: Still a major skin problem and commonly mimicking chronic actinic dermatitis. Our Dermatol Online. 2026;17(3):317-324.

Submission: 02.08.2025; **Acceptance:** 12.10.2025

DOI: 10.7241/ourd.20263.5

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glycol and/or various chemicals, such as ammonia and/or chloroform [3]. In ancient times, dyes were obtained from plants [4]. Henna (*Lawsonia inermis*) is known as one of the most common of these, along with indigo, *Cassia obovata*, or senna, or turmeric, and amla, as well as katam (*Buxus dioica*), black walnut shells, red ochre, and leeks; other ingredients may also be used [5]. Hair dyes are primarily composed of paraphenylenediamine (PPD), resorcinol, or propylene glycol, or sodium ethylenediaminetetraacetic acid (EDTA), or preservatives, and fragrances as the main ingredients [6]. Despite the fact that the patch test is recommended, it is rarely followed [5]. As a result of using hair-dyeing products, a variety of adverse effects can occur [4]. Some of the most common adverse effects include allergic contact dermatitis, irritant contact dermatitis, photo contact dermatitis, contact urticaria, contact leukoderma, contact anaphylaxis, lichenoid eruptions, actinic dermatitis, facial melanosis, and erythema multiforme-like eruptions [3,7-9]. There are several symptoms associated with these reactions, including redness, sores, itching, burning sensations, and discomfort [8]. In some cases, there is no guarantee that these features will become apparent immediately after the tint is applied and processed, but they can become apparent hours or even a day later [3]. Currently, PPD is the most important and most commonly used hair dye in the market today and is also one of the most common allergens [7]. It has been found that the sensitization prevalence to paraphenylenediamine (PPD) has varied from 2% to 12% in Asia, with a relatively higher prevalence found in Asian men than in Asian women [10]. In Europe, the prevalence is 4%, while in North America, the prevalence is 6.2% [11]. In a recent study by Sharquie et al., it has been reported that hair dye dermatitis is on the rise in Iraq, forming an outbreak, with a male-to-female ratio of 5.2:1 and a mean age of 52.3 years [8]. The different types of hair-dyeing systems can be categorized into two main types of hair dyes—oxidative and non-oxidative—as well as in terms of color durability after the application of the dye to the hair strands—temporary, semi-permanent, demi-permanent, and permanent [12-14]. As a result of many studies, it has been established that the dye molecule diffuses into the inner fibers of hair [13]. In the process, the molecules are permeated into the intercuticular regions of the endocuticle, passing through non-keratinized regions and the intracellular cement that fixes the endocuticle in place to reach the intercuticular interface [14]. Later in the process, the keratinized region migrates to the macrofibrils before becoming incorporated into the matrix itself [15]. In temporary and semipermanent non-oxidative dyes, colors are created by interacting with colorful molecules, referred to as dye deposition, because the dye molecules only interact with the hair cuticles [12]. In the case that the molecules penetrate only a small depth into the cortex of the hair, they are considered to be semi-permanent products [11]. Semipermanent products can withstand up to six washes. In the case of demi-permanent oxidative dyes, the color characteristics of these dyes are developed by interaction with an oxidizing agent through the development of oxidation dyes, while the permanent oxidative dyes appear to have longer-lasting color characteristics [14-16]. Using oxidative chemistry, permanent hair dyes are made up of a series of chemicals that must be mixed just before application in order to initiate a chemical reaction [17]. In order to increase the pH of the finished product, these dyes usually contain between 6% and 9% hydrogen peroxide and ammonia as an alkalizing agent [18]. Many permanent hair dyes use PPD as a dye precursor in most black, brown, and blonde shades of hair dye [16]. Two chemical processes take place during the permanent hair-dyeing process [15]. First, there is an oxidation of the melanin pigment, resulting in the natural hair color becoming lighter [14]. As a second step in the process, the dye precursors undergo oxidation [12]. Chromophores are the actual molecules in hair strands that give the hair a new color when they react with each other. In terms of chromophores, only some chromophores are retained within the hair shaft, and most of the others are washed away after coloring has been applied to the hair [16]. Therefore, in order for the dye precursors to diffuse into the hair, they must be oxidized by hydrogen peroxide [11]. This means that the dye precursors, also called intermediates, must then undergo an oxidation reaction based on the hydrogen peroxide oxidation of those precursors in order to produce dye [14]. The intermediates that are typically used in this process are p-diamines and p-aminophenols, and as a primary intermediate, PPD is used in the majority of permanent hair dye products [17].

IMMUNOLOGICAL ASPECTS OF HAIR DYE DERMATITIS

Hair dyes have become an integral part of life for many people nowadays [2]. Unfortunately, such a pursuit of beauty can be accompanied by the development of skin lesions, which for hair dyes, includes eczema, irritant contact dermatitis (ICD), allergic contact dermatitis

(ACD), and contact urticarial [19]. Allergic reactions to cosmetics are predominantly detected in young people around twenty years of age, more often in women, and especially in people with dry and damaged skin. The most common allergens are fragrances and preservatives (p-phenylenediamines), UV chemical filters, lanolin, and its derivatives [19]. The most well-known compounds to cause allergic reactions in hair dyes are p-phenylenediamine [20] and toluene-2,5-diamine, which are used to activate coloring pigments [21]. The reaction severity depends on the allergen's concentration in the product's composition and the duration of its exposure [20].

It is thought that irritant contact dermatitis develops as a result of non-immunological mechanisms and that it is connected with the irritating effect of the numerous ingredients in hair dyes on the skin. ACDs are caused by a more complex mechanism [21]. They are usually caused by delayed-type hypersensitivity, which is caused by direct contact with chemical allergens, leading to the development of delayed-type hypersensitivity in the skin [20]. As a prerequisite for the development of ACD, prior sensitization is required, which is referred to as the induction phase [17]. As soon as the antigen comes into contact with the skin, Langerhans dendritic cells migrate to a lymph node near where the antigen first came in contact with the skin. The CD4+T lymphocytes are induced to proliferate and differentiate into Th1 cells as a result of their reactions to the peptide fragments of the antigen formed [22]. As a result of repeated contact with an allergen, Th1 cells that have already been sensitized are sent to the contact site, activating both the resident macrophages and those migrating to the site [20]. Consequently, there is a predominance of cell infiltration over vascular changes, which leads to the development of inflammation and, in turn, begins the phase of clinical manifestations [22].

Histamine, eicosanoids, and other vasoactive peptides have no significant role in the development of ACD, unlike in other diseases [21]. However, there is a much greater importance given to other types of cytokines, such as the lymphokines produced by Th1 cells, the pro-inflammatory cytokines secreted by macrophages, and the chemokines produced by these cells and stromal elements [23].

Since allergic contact dermatitis is based on a delayed-type allergic reaction, hypersensitivity to a chemical allergen in the composition of hair dyes is determined by numerous factors, primarily the state of the immune system [19]. Those who have a hereditary predisposition to allergic diseases or those whose environment is conducive to chronic infections that create a suitable environment for its development are more likely to develop it [23]. Conventional treatments for allergic reactions include the withdrawal of the causative hair dyes, the use of topical steroids, as well as severe systemic antihistamines that can be administered as an alternative to topical steroids [3].

The objective of the present work is to perform a full clinical and epidemiological evaluation of patients with hair dye dermatitis within a limited period of time.

PATIENTS AND METHODS

Two hundred thirty-four patients complaining of hair dye dermatitis gathered during the period from January 2014 to December 2022 were involved in this cross-sectional, descriptive, observational, case-series, clinical-histopathological study. The study was conducted in accordance with the Declaration of Helsinki. After discussing the nature of the study with all of the patients, informed consent forms were obtained from them. The close-up picture of the object was taken at the same place with a fixed distance and lighting in the same direction. Also, all of the patients who were included in this study accepted the idea of sharing their photos in this study. A full epidemiological and demographic profile was recorded during the study. The scientific name of all dyes used by the patients was paraphenylenediamine (PPD) dye. In order to establish the right clinical diagnosis, a detailed history of the patient was taken along with a thorough physical examination. In addition to the name, age, sex, residence, occupation, atopy history (nasobronchial allergy, asthma, childhood eczema) of the individual, the duration of the lesions, the chief complaints, the associated symptoms including redness, sores, itching, burning sensation, and discomfort, the recurrence, aggravating and relieving factors, the site, type, geographical distribution, the type and duration of hair dye, the work environment, family background, medical history, and drug usage. To confirm the results of biopsies, incisional biopsies were performed for histopathological assessment.

RESULTS

Two hundred thirty-four patients complaining of hair dye dermatitis were considered in the present work; their ages ranged from 32 to 60 years, with a mean

of 50 years, with 189 (80.8%) males and 45 (19.2%) females, with a ratio of 4:1. All patients had applied black hair dye. The frequency of these cases among years showed an upsurge-curve as follows: 2014: 6 (2.6%), 2015: 12 (5.1%), 2016: 42 (17.9%), 2017: 50 (21.4%), 2018: 42 (17.9%), 2019: 33 (14.2%), 2020: 13 (5.5%), March 2021: 6 (2.6%). The years 2020 and 2021 could be excluded because of COVID-19, while during the year 2022 included 30 (12.8%) cases. The sites of rash were as follows: face in 159 (67.9%); neck and V area of the chest in 120 (51.2%); scalp in 60 (25.6%); and limbs and trunk in 60 (25.6%) patients. Two or more sites were affected at the same time. The patterns of face rash were acute angioedema in 32 (13.7%) cases, erythematous dermatitis in 36 (15.4%), and pigmented lichenoid photodermatitis in 166 (70.9%), and this clinical picture mimicked chronic actinic dermatitis (Figs. 1 – 8), (Tables 1 and 2). In addition, 102 (43.6%) patients had facial melanosis as separate or combined with other features of hair dye dermatitis (Fig. 9). Histopathological evaluation demonstrated features of acute dermatitis like acanthosis of the epidermis with spongiosis and intraepidermal blistering, while the dermis revealed superficial perivascular lymphocytic infiltrate (Fig. 10). The chronic cases showed acanthosis of the epidermis with or without parakeratosis, with mild spongiosis. The dermal changes were mainly a superficial perivascular lymphocytic infiltrate (Fig. 11).

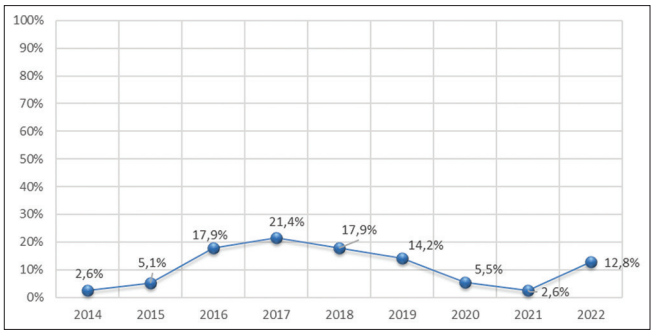

Figure 1: The frequency of hair dye dermatitis cases over the years (n = 234).

Figure 2: 50-year-old male patient showing black hair dye chronic dermatitis simulating chronic actinic dermatitis.

Figure 3: 55-year-old female patient showing black hair dye chronic photodermatitis mimicking chronic actinic dermatitis.

DISCUSSION

Graying hair is a phenomenon currently not completely understood. As a complex multi-factorial process, it is commonly regarded as a result of a complex interplay of nutritional, genetic, and environmental factors. A number of nutritional deficiencies, including vitamin B12 deficiency, severe iron deficiency, chronic protein loss, and copper deficiency, are commonly associated with premature graying of the hair. Low serum ferritin levels as well as low levels of vitamin D3 and calcium in the serum have also been implicated as contributing factors [2,24]. Although any graying of hair that appears before the age of thirty should be considered a variant of vitiligo [25]. An outbreak of hair dye dermatitis has been observed in Iraq in the last ten years, with the frequency of occurrence growing [8]. The data from the present study shows an upsurge curve in the number of cases in the years 2014–2022, with the peak occurring in 2017 (21.4%). Despite this, due to the presence of COVID-19 infections, the years 2020 and 2021 were excluded from the analysis. In a previous study performed by Sharquie et al., the mean age of hair dye dermatitis was 52.3 years, which is mainly a disease of males (83.9%). The male-to-female ratio was 5.2:1, and the frequency of hair dye dermatitis was higher among males. According to the present study, the mean age was 50 years, with 80.8% of the participants

Figure 4: (a) 52-year-old male patient showing chronic lichenoid photodermatitis of the face and forearms mimicking chronic actinic dermatitis. (b) The same 52-year-old male patient showing chronic lichenoid photodermatitis of the face and forearms that mimics chronic actinic dermatitis.

Figure 5: (a) A 49-year-old male patient showing chronic hair dye dermatitis of the face and trunk that mimics chronic actinic dermatitis. (b) The same 60-year-old male patient with hair dye dermatitis of the face and trunk.

being males, with a male-to-female ratio of 4:1. These results are comparable but are in contrast to other reported studies, which have shown a male-to-female ratio of 1.4:1 [8,10,19]. The reason behind this great difference has not been well explained, but the increased use of hair dyes by males in recent years might be a contributing factor. Also, the second reason for this increase among males as they are using a high concentration of hair dye, ranging from black to deep brown, which offers a rapid and long-lasting effect due to the greater concentration of PPD in dark-colored hair dyes than light-colored, which are usually used by women [20].

Figure 6: 55-year-old male patient showing chronic dermatitis of the scalp.

Figure 7: 45-year-old female showing acute hair dye angioedema.

Figure 8: (a) A 60-year-old patient showing hair dye dermatitis of the face and trunk. (b) Hair dye dermatitis of the face and trunk.

According to the present study, the face was the most frequently involved (67.9%); with the others being the neck and V area of the chest (51.2%); the scalp (25.6%); and the limbs and trunk (25.5%). Whereas, in

Table 1: Sociodemographic characteristics of hair dye dermatitis (n=234).

Character	Number	(%)
Age in years:		
Min	32	
Max	60	
Mean	50	
Sex:		
Male	189	(80.8)
Female	45	(19.2)

Table 2: Clinical characteristics of hair dye dermatitis (n=234).

Character	Number	(%)
Site of the rash:		
Face	159	(67.9)
Neck and V area of the chest	120	(51.2)
Scalp	60	(25.6)
Limbs and trunk	60	(25.6)
Face rash patterns:		
Acute angioedema	32	(13.7)
Erythematous dermatitis	36	(15.4)
Pigmented lichenoid photodermatitis	166	(70.9)
Facial melanosis	102	(43.6)

the previous study, it was found that the face (98.2%) was almost always involved, while the scalp (54%) was relatively less common, and the scalp margin was the most common place on the scalp to be affected [8]. Despite having thick skin, the scalp was relatively spared from dye or hair dye, except for the margin. This was due to the thick skin on the scalp making the dye more difficult for the body to absorb, causing sensitization in the affected area. Due to this fact, as the patient's first complaint is not scalp involvement, a diagnosis could easily be missed and delayed. Among cosmetic products, hair dye is one of the leading causes of allergic contact dermatitis, and the most important ingredient in permanent hair dye is PPD. When PPD is oxidized, it produces benzoquinone, P-aminophenol, and N-phenyl-PPD, which are potent sensitizers. It is also important to note that additives, such as pyrogallol and resorcinol, can trigger allergic reactions [10]. There has also been a suggestion that there might be a genetic polymorphism in the skin metabolism of PPD, which could explain why only a few individuals apply hair dyes with variable levels of contact sensitivity [26]. As the distribution of hair dye in the body varies from patient to patient, it is not always easy for physicians to diagnose hair dye dermatitis, especially if the patient is not asked about the use of hair dyes. This results in problems in diagnosing hair dye dermatitis. In the present study, the patterns of face rash were acute angioedema in 13.7% of cases, erythematous dermatitis

Figure 9: (a) A 45-year-old patient showing black hair dye dermatitis and marked facial melanosis. (b) Hair dye dermatitis and marked facial melanosis.

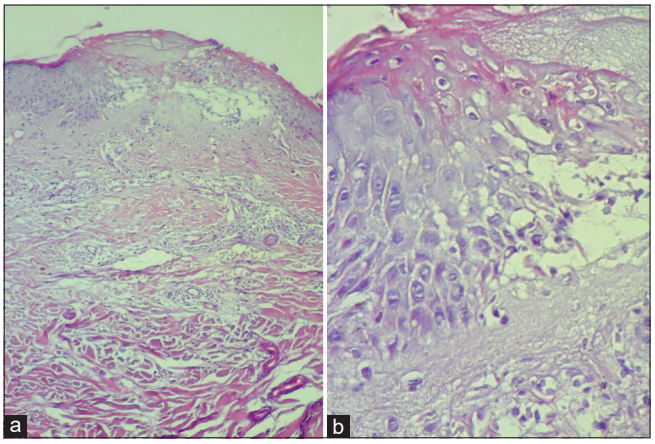

Figure 10: (a) Histopathological picture of hair dye acute dermatitis showing acanthosis of the epidermis with a spongiosis and intraepidermal blistering, with the dermis revealing a superficial perivascular lymphocytic infiltrate (H&E; 10x). (b) Histopathological picture of hair dye acute dermatitis showing acanthosis of the epidermis with a spongiosis and intraepidermal blistering, with the dermis revealing a superficial perivascular lymphocytic infiltrate (H&E; 40x).

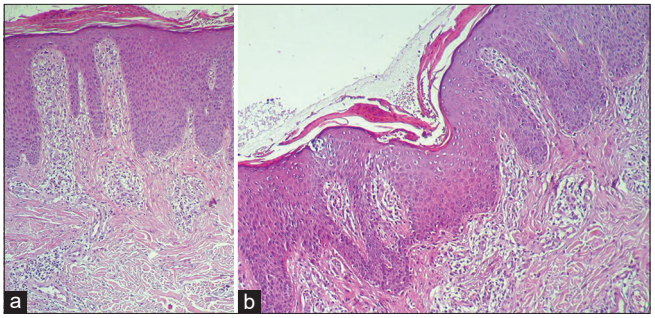

Figure 11: (a) Histopathological picture of chronic hair dye dermatitis showing parakeratosis and acanthosis, with a dermal superficial perivascular lymphocytic infiltrate (H&E; 10x). (b) Histopathological picture of chronic hair dye dermatitis showing parakeratosis and acanthosis, with a dermal superficial perivascular lymphocytic infiltrate (H&E; 10).

in 15.4%, and pigmented lichenoid photodermatitis in 70.9%, while in a previous study conducted by Sharquie et al., the most common clinical presentation of skin rash was dermatitis in 62.5%, lichenoid eruption was seen in 19.9%, actinic dermatitis in 7.1%, facial hyperpigmentation in 5.3%, and angioedema in 5.3% of the patients [8]. Based on the findings of both studies, it seems that pigmented lichenoid photodermatitis is the most predominant clinical presentation, with hair dye dermatitis and facial melanosis being the most commonly reported symptoms. In many patients, irritant dermatitis is the initial presentation. Over time, if hair-dyeing is not discontinued, it might change into delayed-type hypersensitivity (ACD) reactions [19-23]. This chronic clinical and histopathological picture of black hair dye dermatitis affects the face, hands, and even the covered parts of the body, exactly mimicking chronic actinic dermatitis. Hence, black hair dye could be added as a common allergen triggering chronic actinic dermatitis [27].

CONCLUSION

There was a sharp rise and decline curve in black hair dye dermatitis within six years. It was a disease of middle-aged male patients, and the commonest presentation was chronic pigmented lichenoid photodermatitis with or without extrafacial involvement. Many patients presented with mainly facial melanosis alone or part of dermatitis elsewhere. Hair dye dermatitis is now considered a great imitator and mimicker disease as it can simulate many types of dermatitis and facial melanosis, especially cases of chronic actinic dermatitis.

Statement of Human and Animal Rights

All the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the 2008 revision of the Declaration of Helsinki of 1975.

Statement of Informed Consent

Informed consent for participation in this study was obtained from all patients.

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Source of Support: This article has no funding source.

Conflict of Interest: The authors have no conflict of interest to declare.